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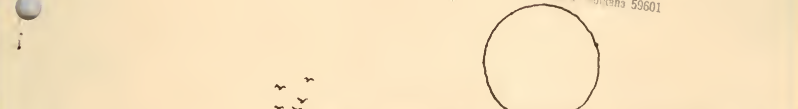
SEEPAGE INVESTIGATIONS

DEADMANS BASIN



Resources Development Internship Program –
Western Interstate Commission for Higher Education

SEEPAGE INVESTIGATION

DEADMAN'S BASIN

By:

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Water Users Association

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-and-

MONTANA DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION
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ABSTRACT

Deadman's Basin Reservoir is an off-stream irrigation water storage site in south central Montana.

Leakage from the earthen outlet canals has caused an increase in the shallow water table down gradient from the canals. This combination of excessive water and large quantities of salts in the soil has caused "saline seep" damage to approximately 430 acres of range land to varying extents.

The topography and clay soil prevent drainage of the affected land. Therefore, the most permanent solution is to stop the water supply at its source - the leaking canals - and then attempt reclamation of the land through careful crop selection.

CONTENTS

ILLUSTRATIONS

INTRODUCTION

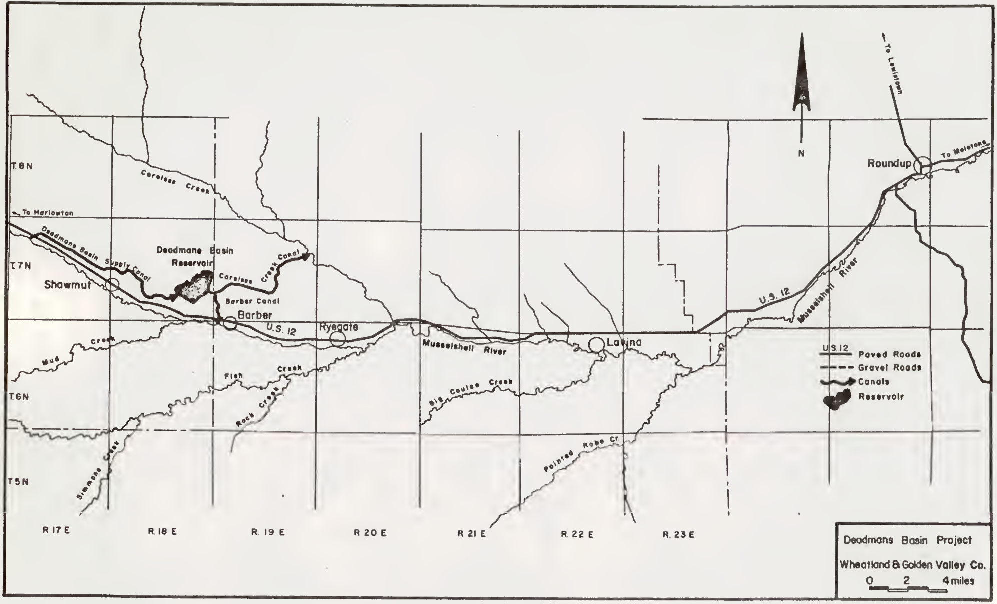
Loss of land productivity is economically disastrous to farmers. A major cause of lost productivity in the dryland farming region is saline seep. Saline seep occurs where the soil is saturated with groundwater that is heavily laden with salts. While flowing along the gradient, the water dissolves the salts from the soil and parent material. The water comes to the surface and, through evapotranspiration, deposits the salts on the soil. As this process continues, the crops can neither utilize the large quantities of water or adapt to the increasing amounts of salts. Gradually more salt-tolerant vegetation takes over, but even these species fail because of the excessive salts resulting in a barren wasteland. In this stage it is often called "alkali ground" or "white alkali" (4) because of the color of the heavy crust of salts. If the source of the water can be determined and controlled, the spread of the "seep" can be checked. The land may be reclaimable depending upon the extent of the damage and the soils involved.

This study of the Deadman's Basin Reservoir project in south-central Montana, undertaken under the auspices of the Western Interstate Commission for Higher Education's (WICHE) Resources Development Program and the Water Resources Division of the Montana Department of Natural Resources and Conservation, sought to analyze the source of the problem, propose solutions and recommend the most economically feasible one for the seepage problem at the reservoir.

The Deadman's Basin Reservoir is an off-stream reservoir which supplies water for irrigation use along the Musselshell River and Careless Creek through the Barber and Careless Creek Canals (figure 1).

The main seepage area is in the bottom land between the heads of the two outlet canals from the reservoir. In this area about 430 acres have been affected by the saline seep. Of this, 210 acres have heavy crusts of the salts.

There are additional minor problems along the outlet canal system. Specifically, the non-saline leakage from the canals-most extensive at fills-and the erosion of the meanders of Careless Creek below its confluence with the Careless Creek Canal (figure 2).



DEADMAN'S BASIN RESERVOIR SYSTEM

Figure 1

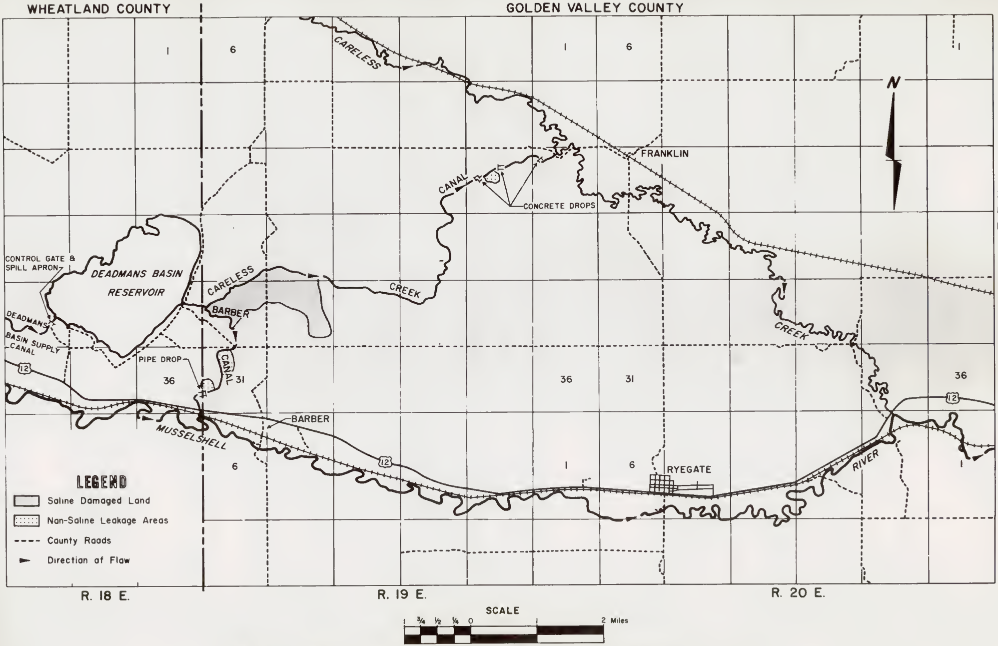


Figure 2 KNOWN LEAKAGE AREAS ALONG DEADMANS BASIN OUTLET CANALS

HISTORY OF DEADMAN'S BASIN

Deadman's Basin Reservoir is an off-stream irrigation water-storage site in the Musselshell River drainage basin. The reservoir itself is located about 21 miles east of Harlowton on U. S. Route 12 in south-central Montana. The purpose of the reservoir is to store spring runoff for irrigation use along the two outlet canals and the Musselshell River as far downstream as Melstone, for a total distance of approximately 80 miles.

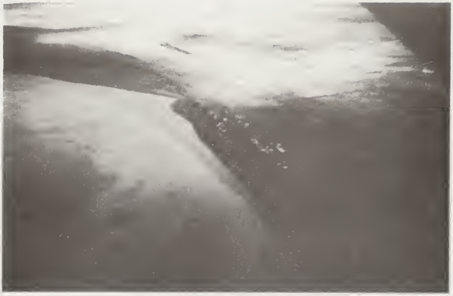
As a point of curiousity, one of the stories told of the origin of the name, Deadman's Basin, is that the area now covered by the reservoir originally contained three small lakes and extensive marshy alkali areas. One evening a sheepherder went out to look after his flocks and he was found dead in the basin the next morning.

The supply canal for Deadman's Basin Reservoir is 11.5 miles long with a capacity of 600 cubic feet per second. Water is from the Musselshell River two miles downstream from Winnecook in Wheatland County (figure 1). There are a few irrigation turnouts along this canal.

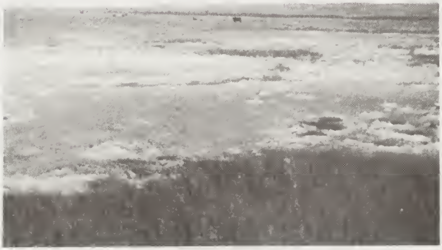
The reservoir, located in Wheatland County, has a storage capacity of 80,570 acre-feet, 4,600 acre-feet of which is dead storage. The water is contained by an earthfilled dam 1,360 feet long and 63 feet high and by a low earthen dike 2,950 feet long. The outlet gate in a wet tower is a 60" x 60" slide gate with a capacity of 1,000 cfs. The outlet canal from the dam flows into a small reregulating pond where the headgates for the Careless Creek and Barber Canals are located (figure 2).

Construction of the Careless Creek Canal was completed in 1941. The Careless Creek Canal has a design capacity of 344 cfs, and is 9.5 miles long and empties into Careless Creek just west of Franklin, Golden Valley County, Montana. Careless Creek joins the Musselshell River four miles east of Ryegate.

In the original outlet canal system, a 50 cfs canal was dug to empty water into "79" Coulee which drains into the Musselshell River. Because of erosion damage in this coulee, a new canal, the Barber Canal, was dug, initially following the route of the small canal, but continuing down to the Musselshell River immediately west of Barber. The Barber Canal, constructed in 1956, has a design capacity of 210 cfs and is 2.85 miles long.



Aerial view of Deadman's Basin Reservoir and the
Major Seepage Area.



Close-up of seep Area showing Alkali Condition.

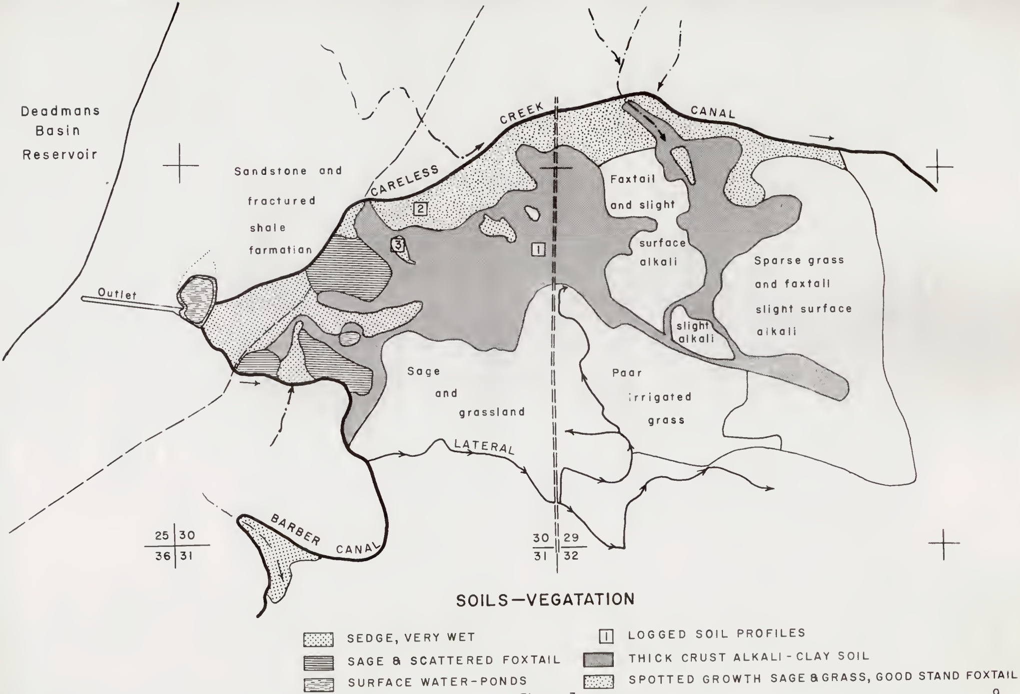

Deadmans Basin Reservoir
Sandstone and fractured shale farmatian
Outlet
CARELESS CREEK CANAL
Faxtail and slight surface alkali
Sparse grass and faxtall slight surface alkali
slight alkali
Sage and grassland
Paar irrigated grass
LATERAL
BARBER CANAL
25 30 36 31
30 29 31 32
1
2
3
SOILS—VEGATATION
SEDGE, VERY WET
SAGE & SCATTERED FOXTAIL
SURFACE WATER-PONDS
LOGGED SOIL PROFILES
THICK CRUST ALKALI-CLAY SOIL
SPOTTED GROWTH SAGE & GRASS, GOOD STAND FOXTAIL

Figure 3

FINDINGS

Historical

The files on the Deadman's Basin Project were reviewed to determine what, if anything, had been written on the seepage problem along the canals. In November of 1949, Mr. R. H. Fifield of the Montana Water Resources Board made a field inspection of the seepage conditions along Careless Creek Canal. At that time he recommended an open drain along the county road just east of the reservoir to stop the seepage at that point and to protect the road. He also suggested "lining sections of the Careless Creek Canal where it is constructed through shale and laminated sand rock." The open drain was constructed but it was not as long nor as deep as was needed to efficiently intercept the seepage. There is no indication if this seepage was saline at that time. No other surveys were made dealing with this problem.

Soil

A soil samples survey of the area was made by Glenn Smith, Soils Scientist and Chief of the Land Resources Section (figure 3). It was found that the alkali areas consist of clay-textured soils with an extremely low permeability and a high amount of salt within the surface 24 inches (Appendix A). The clay soil is just above field capacity moisture for a depth of approximately 40 inches. The drainability of this soil is poor, and any lateral movement of water would be very slow, because of the soil type and the topography.

Sedge, which is very water tolerant, indicates discharge areas of large amounts of water leaking from the canals. The leakage is through the canal bank and bottom which is generally composed of sandstone and shale formations. A large amount of soluable salt in the shale and sandstone is dissolved in the water as the water seeps through these soils. These salts become surface alkali because of the poor soil permeability, and lack of relief cause the deposits of salt on the surface during evapotranspiration.

Unlike saline seep in other areas, the seepage does not appear to be spreading rapidly. The alkali areas are about the same size at the present time as they were on June 25, 1962, when an aerial photo in which the alkali is discernable was taken.

Water Quality

"Salts of calcium, nagnesium, sodium, and potassium may also prove injurious in irrigation water. In excessive quantities these salts reduce the osmotic activity of plants, preventing the absorption of nutrients from the soil. In addition, they may have indirect chemical effects on the metabolism of the plant and may reduce soil permeability, preventing adequate drainage or aeration. The effect of salts on the osmotic activity of plants depends largely on the total amount of salts in the soil solution." (6)

For this study, water samples were taken at eight sites along the Deadman's Basin Reservoir Project and the Musselshell River (figure 4). The samples were analyzed by the Water Quality Bureau Laboratory of the Montana State Department of Health and Environmental Sciences for the major cations (Ca, Mg, Na), anions (HCO_3, CO_3, Cl, SO_4, PO_4), pH and specific electrical conductance (SC) (Appendix B).

This analysis indicated that the salinity hazard is an indicator of the total salts content as reflected by the specific electrical conductance. A specific conductance greater than 750 micromhos/cm indicates a high salinity hazard (3). In the Deadman's Basin Reservoir system the calcium and magnesium cations constituted about two-thirds of the total cations present in the water.

The high sodium concentrations indicated by the water sample analysis for Careless Creek and the Musselshell River may be due to runoff from the irrigated land and the small amount of water in the stream for dilution. The sodium (alkali) hazard, as indicated by the Sodium Absorption Ratio, is the relative hazard of sodium ions replacing absorbed calcium and magnesium ions

in the soil. This replacement damages the soil structure by causing a deflocculated and relatively impermeable soil. However, this problem is slight at this time.

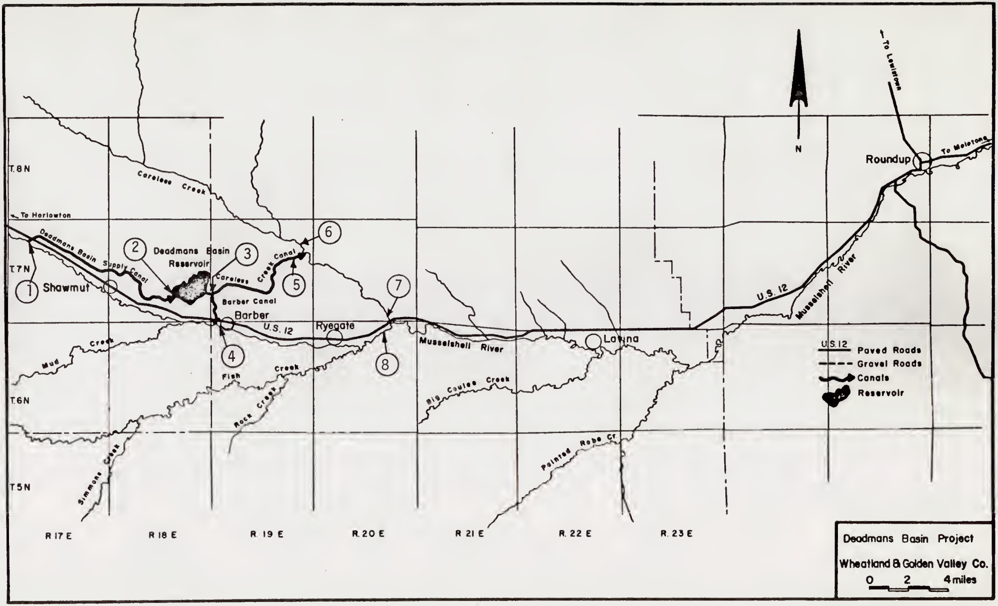
A series of water samples of the Deadman's Basin Reservoir area were taken by Darryld Kautzmann, County Extension Agent for Musselshell and Golden Valley Counties, during the 1972 irrigation season. His test results showed a medium to high salt (salinity) hazard and a low sodium hazard except for Careless Creek above the Careless Creek Canal where the sodium hazard ranged from low to medium. During this series of tests, taken throughout the irrigation season, his tests of the reservoir water showed some deterioration in quality. This may be due to the runoff from the irrigated fields, and to some extent to the concentrating affect of the reservoir due to evaporation.

Water Flow

An attempt was made to determine the amount and areas of most leakage along the canals by taking flow measurements. Three points of measurement were used on each canal; at the gaging stations near the headgates and at two bridges or culverts farther downstream on each canal. Mel McBeath, Hydrographer with the Water Resources Division of the Department of Natural Resources and Conservation, took these measurements with the canals running about one-third full.

Geology

A geological analysis of the canal area made by Jim Halloran, Water Resources Division geologist, showed the soil to be decomposed sandstone which is moderately permeable to water as sandy soil. This decomposed sandstone is underlain by shale (figure 5). These marine formations contain soluable salts which are transported to and deposited on the soil surface as the groundwater is evapotranspired.



WATER SAMPLING SITES (1973)

Figure 4

Sample Site	Ca	Mg	Na	HCO_3	CO_3	CI	SO_4	NO_3	PO_4	LAB. pH	SC	SAR	Field Temp. °C
1) Musselshell River at Deadman's Basin Supply Canal	89	42	85	273	7	6.5	322	0.22	0.03	8.4	800.0	1.9	19
2) Deadman's Basin supply canal at Reservoir	87	47	93	278	2	7.5	349	0.03	0.13	8.4	855.0	2.0	18
3) Deadman's Basin outlet canal below Reservoir Dam	76	44	78	233	0	7.3	333	0.17	0.05	8.3	770.0	1.8	13
4) Barber Canal just above Musselshell River	76	44	76	232	0	7.0	315	0.22	0.05	8.3	760.0	1.7	15
5) Careless Creek Canal above last Concrete Drop	77	44	78	231	0	7.0	330	0.13	0.07	8.3	750.0	1.8	16
6) Careless Creek above Careless Creek Canal	70	73	174	407	0	0.8	498	0.24	0.05	8.3	1110.0	3.5	19
7) Careless Creek above Musselshell River	82	53	110	260	0	9.2	416	0.22	0.07	8.3	915.0	2.3	18
8) Musselshell River just above Careless Creek	89	57	115	267	0	8.5	470	0.22	0.05	8.3	950.0	2.3	19
	← Mg/L →										Micro-mhos/CM @ 25°C		

Day of Sampling (6/13/73) Ambient air temperature: 90°-95°F

TABLE 1 WATER SAMPLE ANALYSIS

Figure 5 GEOLOGY

DISCUSSION

Canal Renovation

The water causing the seepage problem is evidently leaking form the outlet canals. The first of several ways to eliminate or reduce this seepage is to line the canals. There are several types of linings in use at this time. A common one, bentonite clay, provides a good serviceable lining when it is properly installed and maintained. But since the canals at Deadman's Basin stand dry part of the year, the maintenance of the bentonite would be costly. Past use in this area indicates that after a series of wet and dry cycles, the bentonite wears out and leaks as badly as the unlined canals. Since bentonitic materials are available locally, the material could be obtained relatively cheap but the short life expectancy of this lining material for these canals does not justify the expense of installation at the present. Bank stabilization procedures such as soil cement have the same drawbacks as bentonite lining, as they also tend to crack if allowed to dry out.

A second type of lining is called the "membrane" method. In this system the canal is excavated slightly larger than the finished canal, then vinyl sheeting is laid, or a thin coat of asphalt is sprayed into the excavated canal bed. This membrane is then covered with 6 to 12 inches of gravel or free draining soil to protect the membrane from damage. This is an effective and generally economical system, but this lining has a life expectancy of about half that of concrete.

A third type of lining is concrete. This is an initially expensive method but, if properly installed, it presents fewer maintenance problems and generally has a longer life span. The cross sectional area can be smaller than an earthen canal of equal capacity, since concrete has a lower roughness coefficient and can also withstand higher water velocities. This is a universally accepted lining

A proposal that had been considered was to intercept the leakage via a drain pipe or open drain along side the canal and to conduct the water directly to the coulee draining the area. This has been shown to be totally unfeasible because the extremely flat topography would not permit achievement of a good drainage gradient and would aggrevate the ponding in the area.

Two separate plans for lining were considered (figure 6). Plan A involves the minimum amount of lining to effectively cut down the leakage. It would include lining 3,600 feet of the Barber Canal and 2,400 feet of the Careless Creek Canal, or a total of 6,000 feet of lining. Plan B involves lining all sections suspected of contributing to the alkali problem. This plan includes the same 3,600 feet of the Barber Canal but an additional 5,100 feet of lining on the Careless Creek Canal. The estimates of lengths, cost per foot, and total cost for both plans utilizing both concrete and vinyl linings are cited in Table 2. The size of the linings was determined by considering the maximum flows from ten years of flow records for the canals and the original design cross sections.

Two additional areas on the Barber Canal are leaking excessively but lining has not been recommended as they are not causing alkali problems. These two areas, where the canal makes a tight 180° turn while crossing a coulee and immediately before entering the long pipe drop, should be inspected periodically for signs for further deterioration (figure 2).

New Pipe Drop

As an alternative to lining or repairing the canals, the placement of a pipeline about 1 mile southeast of the dam was studied (figure 6). This line was chosen because the reservoir and Musselshell River are closest at this point and there is a break in the rock ridge lying between them. Also, there is a 20-foot dike along the reservoir in this area. The distance from the waterline at the base of the dike to the river is about 3,960 feet, and the elevation difference is about 160 feet. An additional 3,300 feet of pipe would be needed

to form an intake in the nearest low spot in the reservoir. This spot is the west shore of the pre-existent Lake No. 3 about 60 feet below the water surface at the time of the survey. Considering the amount and size of pipe needed, the amount of excavation and the additional water losses because this outlet would be farther upstream than the existing canals, the cost was deemed prohibitive.

Another possible route, which was investigated to avoid the necessarily deep excavation through the dike, was to take the water from the existing outlet and pipe it to the above described path to the river. Because even more pipe and extensive excavation would be involved, this possibility was pursued no further.

Careless Creek

Scouring of oxbows by a creek is a natural phenomenon found on any stream. The rate of scour is determined by the type of earth the stream must cut through, the velocity of the stream.

There is evidence in the bottomland that Careless Creek has changed its course and channel many times. It is continuing to do so.

One way to control this action is to riprap the oxbows. However, on Careless Creek this would be extraordinarily expensive, as there are approximately 100 oxbows in the 7-airmile stretch between the Canal's confluence and the stream's junction with the Musselshell River. The alternative is to keep the water level below the easily scoured blue shale. This can be accomplished to a large extent through careful regulation of the flow through the Careless Creek Canal.

The amount of scouring of the meanders above the confluence of Careless Creek and Careless Creek Canal is about the same as on the lower reaches of the stream. However, the banks are somewhat stabilized by heavy brush growth in the upstream area.

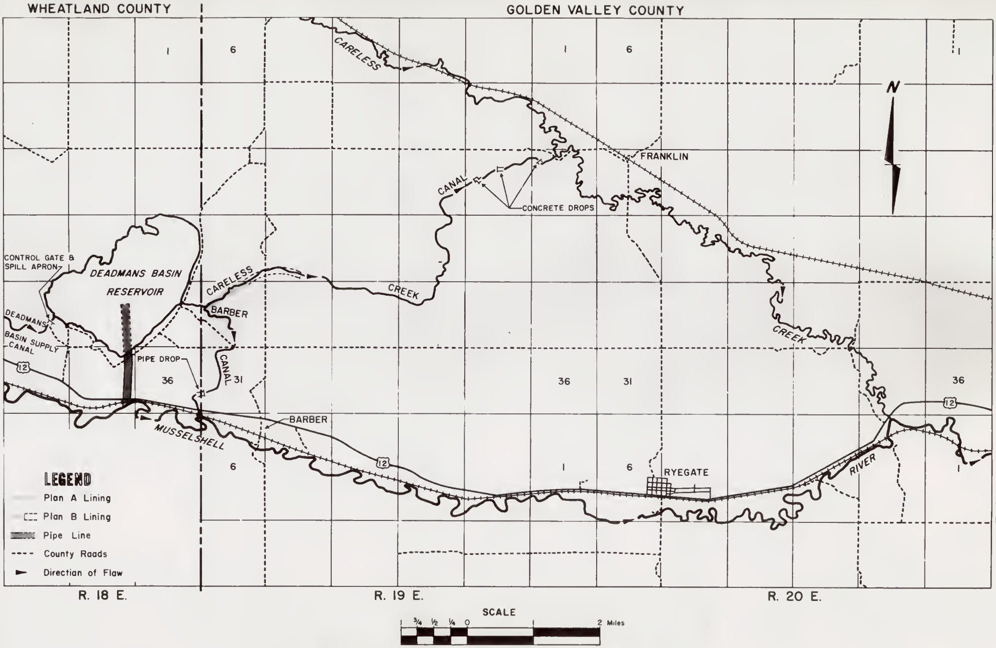


Figure 6 PROPOSED CANAL LINING AND PIPE LINE

CANAL LINING COST ESTIMATES

Plan A - Minimum Lining Requirements

Canal	Length Ft	Concrete+ $/L.F.	Total Cost	Vinyl++ $/L.F.	Total Cost
Barber	3,600	$ 35.00	$126,000	$ 20.00	$72,000
Careless Creek	2,400	35.00	84,000	20.00	48,000
TOTAL	6,000		$210,000		$120,000

Plan B - Maximum Lining Requirements

Canal	Length Ft	Concrete+ $/L.F.	Total Cost	Vinyl++ $/L.F.	Total Cost
Barber	3,600	$ 35.00	$126,000	$ 20.00	$72,000
Careless Creek	7,500	35.00	262,500	20.00	$150,000
TOTAL	11,100		$388,500		$222,000

+Projected Life - 40 years
++Projected Life - 20 years

	Total Cost	Annual Cost*	Cost per Acre-ft/year**
Plan A			
Concrete lining	$210,000	$12,238.80	$.60
Vinyl Lining	120,000	9,633.60	.47
Plan B			
Concrete lining	388,500	22,641.78	1.11
Vinyl lining	222,000	17,822.16	87

*based on 5% interest on a 40-year loan for concrete lining
**based on 20,423 acre-feet of current contracts for water from Deadman's Basin

Table 2

Water Management

One of the main sources of trouble along Careless Creek Canal and Careless Creek is the large volume of water conveyed by these canals. Therefore, an analysis of the location and amount of present water usage is recommended. The purpose would be threefold: 1) to determine the best path for transporting the water to the user; 2) to avoid additional damage to the canal and Careless Creek; 3) to determine the amount of water that would have to be released to meet the demand and losses. This analysis would be difficult because there are no flow measurement devices at any of the turnouts along the canal, creek, or Musselshell River, and because the Musselshell River is not an adjudicated stream.

It appears that the main water delivery to the river could be accomplished through the present Barber Canal.

The reregulating pond at the head of the canals is aggrevating the seepage problem as it is located on a permeable sandstone formation. There is no apparent necessity for the existance of this pond.

Land

About 210 acres of land have a thick white alkali crust, and an additional 220 acres have thin surface coating of alkali. This land is located mainly in Sections 29 and 30, Township 7 North, Range 19 East, Golden Valley County. Fifty acres in these sections are marsh areas with surface water and mostly sedge and cattail growth. Both sedge and cattail will tolerate large amounts of salts.

Reclamation of this land will be difficult. The large area, flat topography and tightness of the clay soil make artificial drainage of this land very expensive. Using artificial drainage or flushing of the salts also presents a danger to the existing stock watering ponds on the coulee draining the area.

Treatment with gypsum or a pH lowering chemical, such as sulfur, sulfuric acid or ferrous sulfate, is a commonly used method for alleviating the salinity problem (3). However, this is necessarily a short term solution.

Both economically and technically, the most feasible reclamation plan would be to establish a salt tolerant crop on the land. There are several salt tolerant plants which offer possible solutions. Tall wheat grass and western wheat grass are tolerant of salinity and well adapted to dryland farming methods. Beardless wild rye is both salt and water tolerant and seed is available. Tall wheat grass and beardless wild rye are known to grow in patches of "white aklakli." Alkali sacaton is tolerant of both salt and water and is growing in the area, but seed is not available at the present time. Alfalfa, while salt tolerant, cannot adapt to the high water table so it is unsuitable for this area. For this area with this combination of salinity and a high water table, beardless wild rye would probably be the most suitable crop.

Planting the seed will present some difficulty as the ground is too soft to support the weight of a tractor. Broadcasting offers an alternative to attempting to plow the land. Since some areas are too wet to walk on this alternative will present some difficulty.

Another possibility is the purchase of the most severely damaged land, about 200 acres. The price should be that as similar undamaged rangeland in the area. Tentatively, this would be a temporary action until the ground could be reclaimed. Perhaps this land could be used to experiment with the reclamation of "alkali ground."

CONCLUSIONS

The tests of water quality of the reservoir system indicated that overall the water would be considered good for irrigation of most crops under most conditions. Therefore, the alkali problem is apparently arising from the salts in the soil, shales, sandstone and other parent material which are leached and brought to the surface by the water where they are deposited during evapotranspiration.

Flow measurement in the canals were inconclusive as the measured losses were less than the maximum accuracy of this method of flow measurement.

In the Deadman's Basin area treatment of the soil with a pH lowering chemical would be a very temporary solution because of the high water table and the continued leakage from the outlet canals. The cost of such chemical treatment would be great.

While both the Barber and the Careless Creek Canals are in need of lining, it seems advisable to use the Barber Canal more heavily than currently practiced in order to reduce the water losses due to leakage and to keep the water level low enough in Careless Creek to reduce the erosion of the oxbows and the subsequent sloughing off of the meadow land in its lower reaches.

RECOMMENDATIONS

It is recommended that a study of the water useage along the outlet canals, Careless Creek and the Musselshell River be undertaken. This would provide a basis for a water management program. To provide data for this type of study, flow-measuring devices should be installed at all irrigation turnouts of the water purchasers.

Use the Careless Creek Canal to serve primarily the water users along the canal itself and the creek, and delivery through the Barber Canal would provide the bulk of the water for downstream use on the Musselshell. Reduced flows in the Careless Creek would flow in the gravel base, thus reducing the scouring of the blue shale.

The re-regulating pond below the Deadman's Basin Reservoir should be filled in with only channels extending from the main outlet canal to the Barber and Careless Creek Canals. Because of the soils and geological conditions the re-regulation pond is a source of leakage. The range stock's need for a ford and drinking water could be met by providing a short section of the canal with low side slopes of perhaps 3 or 4:1. Concrete aprons would possibly have to be constructed for the headgates of the canals to prevent their washing out. The rest of the new canal sections may have to be lined to prevent leakage.

At this time it seems to be economically unfeasible to line the canals with concrete, vinyl, or bentonite materials. The next most economical alternative would be to purchase all the effected land or just the most heavily crusted alkali lands. Partial reclamation of the effected land could be initiated by broadcasting seed of a salt and water tolerant plant species, whether all or part of the effected land is bought. Finally the last and of course the most economical would be to do nothing. My recommendation would be to choose the alternative that the Deadman's Water Users Association can afford and that would be acceptable to the effected land owners.

is it really in the long run?

Beartooth the Foreland

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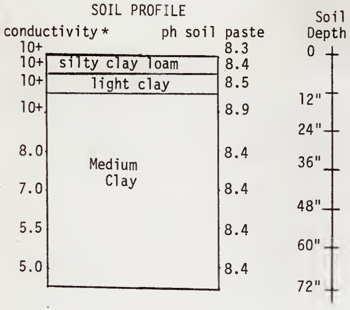
APPENDIX A

SOIL PROFILES

Hole No. 1 - Section 30



Laboratory Samples

Surface - conductivity instrument measures only to 10.0 millimhos. Estimated reading above that would be at least 20.0 millimhos.

0-6" - conductivity above 10.0 on conductivity instrument. Estimated reading would be at least 20.0 millimhos.

6-12" - conductivity above 10.0 millimhos estimated reading at least 18.0 millimhos.

12-24" - conductivity above 10.0 millimhos estimated reading at least 15.0 millimhos.

Salt content too high for any grass.

Hole dug along county road in white large salt spot. The sparse vegetation is spots of alkali sacaton and foxtail. A small shallow drain next to the road is growing coarse sedge. Also, a small area 200 feet NW is growing sedge, which indicates a discharge area of seepage water.

0 - 6" Silty clay loam, sticky, saturated.

6 - 12" Dark gray brown, very sticky & plastic, staturated, light clay.

12 - 72" Medium clay, dark gray brown, very plastic, saturated, with scattered small pockets of gypsum crystals 48 - 72". Few thin lenses of water below 36".

Water table 24 hours after digging - 60 inches.

*Conductivity of saturation extract from the soil, expressed as millimhos/cm at 25°C

Hole No. 2 - Section 30 (150 feet down slope from canal)

Soil Depth	Conductivity*	pH on Soil Paste
0-12	1.3	8.1
12-24	.96	8.2
24-40	.55	8.3
40-60	.28	8.3
60-72	.26	8.2
72-84	.29	8.2
84-96	.31	8.3
96-108	.39	8.2
108-120	.45	8.2

Laboratory analysis show a very low conductivity-(salts) for this soil. The foxtail indicates wetting of upper profile for a good length of time. Leaching may have taken place. There is no reclamation problem appearing, and grass would improve if seepage stopped. Sowing of native grass would be advisable now if range is improved.

The area just south of the canal and north of the NE corner of section 30 is higher in elevation than the clay area. Hole No. 2 was drilled to identify canal leakage and soil characteristics.

0 - 12" Sandy clay loam, lt. brown, hard dry, sticky when moist, angular blocky, few mottles.

12 - 24" Lt. brown, friable, slightly moist snady clay loam.

24 - 40" Gray brown, firm, moist, clay loam.

40 - 60" Gray brown, firm, very moist, loam.

60 - 72" Gray brown, firm, very moist near field capacity, sandy clay loam.

72 - 84" Gray brown, field capacity moisture, slightly sticky, clay loam.

84 - 96" Gray brown, sticky near saturation, clay loam.

96 - 108" Gray brown, saturated, very moist, silty clay loam.

108 - 120" Gray brown, water table, very sticky, silty clay loam.

Vegetation - sparse sage brush, stand killed out by seepage. Foxtail thick stand and sparse wheat grass. Area shows signs of seepage.

Water table 18 hours after hole augered - 6 ft. 8 in.

*Conductivity of saturation extract from the soil, expressed as millimhos/cm at 25°C

Hole No. 3 - Section 30

Soil Depth	Conductivity*	pH on Soil Paste
0-12	.44	7.4
12-24	.40	7.9
24-48	.30	8.0
48-60	.31	8.0
60-72	.44	7.8

Hole in seepage discharge area. Excessive leaching has occurred, and salts are lower than in normal soil without leaching.

The large areas of dark green sedge growth were not investigated because of the excessive amount of surface seepage. The water is leaking from canals at such a large quantity that small ponds appear. A representative boring was drilled in a small sedge growth area.

0 - 12" Lt. gray brown, moist, sandy loam.

12 - 24" Gray brown, field capacity moist, sticky, sandy clay loam.

24 - 48" Saturated, lt. gray brown, sticky. Some very thin sand lenses. Water table est. at 36", sandy clay loam.

48 - 60" Saturated, sticky, clay loam.

60 - 72" Saturated, lt. clay, sticky and plastic, light clay.

Vegetation sedge, showing outbreak of large amount of moisture.

The area is at least 5 ft. lower elevation than canal. May be moisture backing up from medium area down slope which is thick crusted alkali.

Water table 17 hours after digging - 26 inches.

*Conductivity of saturation extract from the soil, expressed as millimhos/cm at 25°C

APPENDIX B

WATER ANALYSIS REPORTS

The ideas and opinions expressed
in this report
are those of the author.
They do not necessarily reflect
the views of the
WICHE Commissioners or WICHE staff.

The Resources Development Internship Program
has been financed during 1973 by grants
from the
Economic Development Administration,
Jessie Smith Noyes Foundation,
National Endowment for the Humanities,
National Science Foundation
and by more than one hundred community
agencies throughout the West.

In the interest of resource conservation
and environmental improvement, this report
has been printed on recycled paper.

THE RESOURCES DEVELOPMENT INTERNSHIP PROGRAM

The preceding report was completed by a WICHE intern during the summer of 1973 This intern's project was part of the Resources Development Internship Program administered by the Western Interstate Commission for Higher Education (WICHE).

The purpose of the internship program is to bring organizations involved in community and economic development, environmental problems and the humanities together with institutions of higher education and their students in the West for the benefit of all.

For these organizations, the intern program provides the problem-solving talents of student manpower while making the resources of universities and colleges more available. For institutions of higher education, the program provides relevant field education for their students while building their capacity for problem-solving.

WICHE is an organization in the West uniquely suited for sponsoring such a program. It is an interstate agency formed by the thirteen western states for the specific purpose of relating the resources of higher education to the needs of western citizens. WICHE has been concerned with a broad range of community needs in the West for some time, insofar as they bear directly on the well-being of western peoples and the future of higher education in the West. WICHE feels that the internship program is one method for meeting its obligations within the thirteen western states. In its efforts to achieve these objectives, WICHE appreciates having received the generous support and assistance of the Economic Development Administration, the Jessie Smith Noyes Foundation, the National Endowment for the Humanities, the National Science Foundation, and of innumerable local leaders and community organizations, including the agency that sponsored this intern project.

For further information, write Bob Hullinghorst, Director, Resources Development Internship Program, WICHE, Drawer "P", Boulder, Colorado, 80302, (303) 443-6144.

This report was completed by the following intern:

Name: JoAnn E. Vorozilchak

Address: Box 402 Mueller Apts.
501 W. Granite Street
Butte, Montana 59701

Immediately prior to this internship, the intern was a student at:

College: Montana College of Mineral Science and Technology

Major Field: Environmental Engineering

Year in School: B.S. June 1975

This intern report was read and accepted by a staff member at:

Agency: Engineering Bureau - Water Resources Division

Address: Department of Natural Resources and Conservation
Mitchell Building
Helena, Montana 59601

If you have further comments about this intern report, please write or phone:

Bob Hullinghorst, Director
Resources Development Internship Program
Western Interstate Commission for Higher Education
P.O. Drawer "P"
Boulder, Colorado 80302

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WATER QUALITY BUREAU-MONT STATE HEALTH DEPT.   HELENA, MONTANA 59601

WATER QUALITY ANALYSIS

STATE	MONTANA	COUNTY	WHEATLAND
LATITUDE-LONGITUDE		LOCATION	07N 17E 08BC
SAMPLE TYPE	STREAM	LAB NO.	73-0680
GEOLOGICAL SOURCE		SAMPLE OR BOTTLE NO.	1
DRAINAGE BASIN	40A	AGENCY AND STATION CODE	WRB
DATE SAMPLED	06-13-73	DEPTH WATER ENTERS WELL	
TIME SAMPLED	1513	SWL ABOVE(+) OR BELOW GS	
DATE ANALYZED	06-22-73	ALTITUDE OF SAMPLE POINT	
SAMPLE HANDLING	1100	WATER FLOW RATE	
METHOD SAMPLED	BOTTLE	FLOW MEAS METHOD	
SANITARY CONDITION	4	PRINCIPAL USE OF WATER	MULTIPLE

PROJECT DEADMANS BASIN PROJECT   VOROZILCHAK

REMARKS MUSSELSHELL R AT DEADMANS BASIN SUPPLY CANAL

PARAMETERS REPORTED IN MILLIGRAMS PER LITER EXCEPT AS INDICATED

	MG/L	MEQ/L		MG/L	MEQ/L
CALCIUM (CA)	89.	4.441	BICARBONATE(HCO3)	273.	4.479
MAGNESIUM (MG)	42.	3.455	CARBONATE (CO3)	7.	0.240
SODIUM (NA)	85.	3.697	HYDROXIDE (OH)	0.	0.000
POTASSIUM (K)			CHLORIDE (CL)	6.5	0.183
TOT. IRON (FE)			SULFATE (SO4)	322.	6.704
MANGANESE (MN)			NITRATE (NO3)	.22	0.004
ALUMINUM (AL)			FLUORIDE (F)		
SILICA (SIO2)			PHOSPHATE (PO4)	.03	0.001
		------			------
TOTAL CATIONS		11.594	TOTAL ANIONS		11.611

STANDARD DEVIATION OF CATION-ANION BALANCE 0.06 SIGMA

LABORATORY PH	8.40	CARBONATE HARDNESS AS CACO3	248
FIELD TEMPERATURE	19.0 C	NON-CARB. HARDNESS AS CACO3	146
CALCULATED DISSOLVED SOLIDS	825.2	TOTAL HARDNESS AS CACO3	394
EVAPORATED SOLIDS AT 105 C		TOTAL ALKALINITY AS CACO3	248
SPECIFIC CONDUCTANCE IN		LANGLIER SATURATION INDEX	
MICROMHOS/CM AT 25 C	800.0	RYSNAR STABILITY INDEX	
SODIUM ADSORPTION RATIO	1.9	TECH. CORROSION INDEX	

ADDITIONAL PARAMETERS

AA CALCIUM (CA) 89.   AA MAGNESIUM (MG) 42.

NOTE. PARAMETERS ARE TOTAL DISSOLVED UNLESS LABELED TR-TOTAL RECOVERABLE

DILUTE SPECIFIC CONDUCTANCE   PERCENT REACTANCE VALUES

				CA	MG	NA	K	CL	SO4	HCO3	CO3	NO3
MEAS DSC	0.	CALC DSC	1299.	CA	MG	NA	K	CL	SO4	HCO3	CO3	NO3
CALCULATED MEQ/L	0.0			38	30	32	0	2	58	39	2	0

ANALYST MG   PROCESSING PROGRAM 72(REV3)

NOTE. IN CORRESPONDENCE RELATED TO THIS ANALYSIS REFER TO NUMBER 73-0680

WATER QUALITY BUREAU-MONT STATE HEALTH DEPT. HELENA, MONTANA 59601

WATER QUALITY ANALYSIS

STATE	MONTANA	COUNTY	WHEATLAND
LATITUDE-LONGITUDE		LOCATION	07N 18E 27BC
SAMPLE TYPE	CANAL	LAB NO.	73-0686
GEOLOGICAL SOURCE		SAMPLE OR BOTTLE NO.	2
DRAINAGE BASIN	40A	AGENCY AND STATION CODE	WRB
DATE SAMPLED	06-13-73	DEPTH WATER ENTERS WELL	
TIME SAMPLED	1018	SWL ABOVE(+) OR BELOW GS	
DATE ANALYZED	06-22-73	ALTITUDE OF SAMPLE POINT	
SAMPLE HANDLING	1100	WATER FLOW RATE	
METHOD SAMPLED	BOTTLE	FLOW MEAS METHOD	
SANITARY CONDITION	3	PRINCIPAL USE OF WATER	MULTIPLE

PROJECT DEADMANS BASIN PROJECT VOROZILCHAK

REMARKS DEADMANS BASIN SUPPLY CANAL AT RESERVOIR

PARAMETERS REPORTED IN MILLIGRAMS PER LITER EXCEPT AS INDICATED

	MG/L	MEQ/L		MG/L	MEQ/L
CALCIUM (CA)	87.	4.341	BICARBONATE (HCO3)	278.	4.549
MAGNESIUM (MG)	47.	3.866	CARBONATE (CO3)	2.	0.080
SODIUM (NA)	93.	4.045	HYDROXIDE (OH)	0.	0.000
POTASSIUM (K)			CHLORIDE (CL)	7.5	0.211
TOT. IRON (FE)			SULFATE (SO4)	349.	7.266
MANGANESE (MN)			NITRATE (NO3)	.03	0.000
ALUMINUM (AL)			FLUORIDE (F)		
SILICA (SIO2)			PHOSPHATE (PO4)	.13	0.004
TOTAL CATIONS		12.253	TOTAL ANIONS		12.111

STANDARD DEVIATION OF CATION-ANION BALANCE -0.48 SIGMA

LABORATORY PH	8.40	CARBONATE HARDNESS AS CACO3	236
FIELD TEMPERATURE	18.0 C	NON-CARB. HARDNESS AS CACO3	175
CALCULATED DISSOLVED SOLIDS	863.6	TOTAL HARDNESS AS CACO3	410
EVAPORATED SOLIDS AT 105 C		TOTAL ALKALINITY AS CACO3	236
SPECIFIC CONDUCTANCE IN		LANGLIER SATURATION INDEX	
MICROMHOS/CM AT 25 C	855.0	RYSNAR STABILITY INDEX	
SODIUM ADSORPTION RATIO	2.0	TECH. CORROSION INDEX	

ADDITIONAL PARAMETERS

AA CALCIUM (CA) 87. AA MAGNESIUM (MG) 47.

NOTE. PARAMETERS ARE TOTAL DISSOLVED UNLESS LABELED TR-TOTAL RECOVERABLE

DILUTE SPECIFIC CONDUCTANCE

MEAS DSC 0. CALC DSC 1363.

CALCULATED MEQ/L 0.0

PERCENT REACTANCE VALUES

CA	MG	NA	K	CL	SO4	HCO3	CO3	NO3
35	32	33	0	2	60	38	1	0

ANALYST MG PROCESSING PROGRAM 72(REV3)

NOTE. IN CORRESPONDENCE RELATED TO THIS ANALYSIS REFER TO NUMBER 73-0686

WATER QUALITY BUREAU-MONT STATE HEALTH DEPT. HELENA, MONTANA 59601

WATER QUALITY ANALYSIS

STATE	MONTANA	COUNTY	WHEATLAND
LATITUDE-LONGITUDE		LOCATION	07N 18E 25AC
SAMPLE TYPE	CANAL	LAB NO.	73-0685
GEOLOGICAL SOURCE		SAMPLE OR BOTTLE NO.	3
DRAINAGE BASIN	40A	AGENCY AND STATION CODE	WRB
DATE SAMPLED	06-13-73	DEPTH WATER ENTERS WELL	
TIME SAMPLED	1045	SWL ABOVE(+) OR BELOW GS	
DATE ANALYZED	06-29-73	ALTITUDE OF SAMPLE POINT	
SAMPLE HANDLING	1100	WATER FLOW RATE	
METHOD SAMPLED	BOTTLE	FLOW MEAS METHOD	
SANITARY CONDITION	3	PRINCIPAL USE OF WATER	MULTIPLE

PROJECT DEADMANS BASIN PROJECT VOROZILCHAK

REMARKS DEADMANS BASIN CANAL BELOW RESERVOIR DAM

PARAMETERS REPORTED IN MILLIGRAMS PER LITER EXCEPT AS INDICATED

	MG/L	MEQ/L		MG/L	MEQ/L
CALCIUM (CA)	76.	3.792	BICARBONATE(HCO3)	233.	3.819
MAGNESIUM (MG)	44.	3.620	CARBONATE (CO3)	0.	0.0
SODIUM (NA)	78.	3.393	HYDROXIDE (OH)	0.	0.000
POTASSIUM (K)			CHLORIDE (CL)	7.3	0.204
TOT. IRON (FE)			SULFATE (SO4)	333.	6.938
MANGANESE (MN)			NITRATE (NO3)	.17	0.003
ALUMINUM (AL)			FLUORIDE (F)		
SILICA (SIO2)			PHOSPHATE (PO4)	.05	0.002
		------			------
TOTAL CATIONS		10.805	TOTAL ANIONS		10.966

STANDARD DEVIATION OF CATION-ANION BALANCE 0.58 SIGMA

LABORATORY PH	8.30	CARBONATE HARDNESS AS CACO3	191
FIELD TEMPERATURE	13.0 C	NON-CARB. HARDNESS AS CACO3	180
CALCULATED DISSOLVED SOLIDS	771.7	TOTAL HARDNESS AS CACO3	371
EVAPORATED SOLIDS AT 105 C		TOTAL ALKALINITY AS CACO3	191
SPECIFIC CONDUCTANCE IN		LANGLIER SATURATION INDEX	
MICROMHOS/CM AT 25 C	770.0	RYSNAR STABILITY INDEX	
SODIUM ADSORPTION RATIO	1.8	TECH. CORROSION INDEX	

ADDITIONAL PARAMETERS

AA CALCIUM (CA) 76. AA MAGNESIUM (MG) 44.

NOTE. PARAMETERS ARE TOTAL DISSOLVED UNLESS LABELED TR-TOTAL RECOVERABLE

DILUTE SPECIFIC CONDUCTANCE

MEAS DSC 0. CALC DSC 1227.

CALCULATED MEQ/L 0.0

PERCENT REACTANCE VALUES

CA	MG	NA	K	CL	SO4	HCO3	CO3	NO3
35	33	31	0	2	63	35	0	0

ANALYST MG PROCESSING PROGRAM 72(REV3)

NOTE. IN CORRESPONDENCE RELATED TO THIS ANALYSIS REFER TO NUMBER 73-0685

WATER QUALITY BUREAU-MONT STATE HEALTH DEPT.   HELENA, MONTANA 59601

WATER QUALITY ANALYSIS

STATE	MONTANA	COUNTY	WHEATLAND
LATITUDE-LONGITUDE		LOCATION	06N 19E 04CB
SAMPLE TYPE	CANAL	LAB NO.	73-0684
GEOLOGICAL SOURCE		SAMPLE OR BOTTLE NO.	4
DRAINAGE BASIN	40A	AGENCY AND STATION CODE	WQB
DATE SAMPLED	06-13-73	DEPTH WATER ENTERS WELL	
TIME SAMPLED	1240	SWL ABOVE (+) OR BELOW GS	
DATE ANALYZED	06-29-73	ALTITUDE OF SAMPLE POINT	
SAMPLE HANDLING	1100	WATER FLOW RATE	
METHOD SAMPLED	BOTTLE	FLOW MEAS METHOD	
SANITARY CONDITION	4	PRINCIPAL USE OF WATER	MULTIPLE

PROJECT DEADMANS BASIN PROJECT   VOROZILCHAK

REMARKS BARBER CANAL JUST ABOVE MUSSELSHELL R

PARAMETERS REPORTED IN MILLIGRAMS PER LITER EXCEPT AS INDICATED

	MG/L	MEQ/L		MG/L	MEQ/L
CALCIUM (CA)	76.	3.792	BICARBONATE (HCO3)	232.	3.799
MAGNESIUM (MG)	44.	3.620	CARBONATE (CO3)	0.	0.0
SODIUM (NA)	76.	3.306	HYDROXIDE (OH)	0.	0.000
POTASSIUM (K)			CHLORIDE (CL)	7.0	0.197
TOT. IRON (FE)			SULFATE (SO4)	315.	6.558
MANGANESE (MN)			NITRATE (NO3)	.22	0.004
ALUMINUM (AL)			FLUORIDE (F)		
SILICA (SIO2)			PHOSPHATE (PO4)	.05	0.002
TOTAL CATIONS		10.718	TOTAL ANIONS		10.560

STANDARD DEVIATION OF CATION-ANION BALANCE -0.58 SIGMA

LABORATORY PH	8.30	CARBONATE HARDNESS AS CACO3	190
FIELD TEMPERATURE	15.0 C	NON-CARB. HARDNESS AS CACO3	181
CALCULATED DISSOLVED SOLIDS	750.1	TOTAL HARDNESS AS CACO3	371
EVAPORATED SOLIDS AT 105 C		TOTAL ALKALINITY AS CACO3	190
SPECIFIC CONDUCTANCE IN		LANGLIER SATURATION INDEX	
MICROMHOS/CM AT 25 C	760.0	RYSNAR STABILITY INDEX	
SODIUM ADSORPTION RATIO	1.7	TECH. CORROSION INDEX	

ADDITIONAL PARAMETERS

AA CALCIUM (CA) 76.   AA MAGNESIUM (MG) 44.

NOTE. PARAMETERS ARE TOTAL DISSOLVED UNLESS LABELED TR-TOTAL RECOVERABLE

DILUTE SPECIFIC CONDUCTANCE   PERCENT REACTANCE VALUES

				CA	MG	NA	K	CL	SO4	HCO3	CO3	NO3
MEAS DSC	0.	CALC DSC	1194.									
CALCULATED MEQ/L	0.0			35	34	31	0	2	62	36	0	0

ANALYST MG   PROCESSING PROGRAM 72(REV3)

NOTE. IN CORRESPONDENCE RELATED TO THIS ANALYSIS REFER TO NUMBER 73-0684

WATER QUALITY BUREAU-MONT STATE HEALTH DEPT. HELENA, MONTANA 59601

WATER QUALITY ANALYSIS

STATE	MONTANA	COUNTY	GOLDEN VALLEY
LATITUDE-LONGITUDE		LOCATION	07N 19E 13BA
SAMPLE TYPE	CANAL	LAB NO.	73-0683
GEOLOGICAL SOURCE		SAMPLE OR BOTTLE NO.	5
DRAINAGE BASIN	40A	AGENCY AND STATION CODE	WRB
DATE SAMPLED	06-13-73	DEPTH WATER ENTERS WELL	
TIME SAMPLED	1340	SWL ABOVE(+) OR BELOW GS	
DATE ANALYZED	06-29-73	ALTITUDE OF SAMPLE POINT	
SAMPLE HANDLING	1100	WATER FLOW RATE	
METHOD SAMPLED	BOTTLE	FLOW MEAS METHOD	
SANITARY CONDITION	4	PRINCIPAL USE OF WATER	MULTIPLE

PROJECT DEADMANS BASIN PROJECT VOROZILCHAK

REMARKS CARELESS CANAL ABOVE LAST CONCRETE DROP

PARAMETERS REPORTED IN MILLIGRAMS PER LITER EXCEPT AS INDICATED

	MG/L	MEQ/L		MG/L	MEQ/L
CALCIUM (CA)	77.	3.842	BICARBONATE(HCO3)	231.	3.779
MAGNESIUM (MG)	44.	3.620	CARBONATE (CO3)	0.	0.0
SODIUM (NA)	78.	3.393	HYDROXIDE (OH)	0.	0.000
POTASSIUM (K)			CHLORIDE (CL)	7.0	0.197
TOT. IRON (FE)			SULFATE (SO4)	330.	6.878
MANGANESE (MN)			NITRATE (NO3)	.13	0.002
ALUMINUM (AL)			FLUORIDE (F)		
SILICA (SIO2)			PHOSPHATE (PO4)	.07	0.002
TOTAL CATIONS		10.855	TOTAL ANIONS		10.859

STANDARD DEVIATION OF CATION-ANION BALANCE 0.01 SIGMA

LABORATORY PH	8.30	CARBONATE HARDNESS AS CACO3	189
FIELD TEMPERATURE	16.0 C	NON-CARB. HARDNESS AS CACO3	184
CALCULATED DISSOLVED SOLIDS	767.1	TOTAL HARDNESS AS CACO3	373
EVAPORATED SOLIDS AT 105 C		TOTAL ALKALINITY AS CACO3	189
SPECIFIC CONDUCTANCE IN		LANGLIER SATURATION INDEX	
MICROMHOS/CM AT 25 C	750.0	RYSNAR STABILITY INDEX	
SODIUM ADSORPTION RATIO	1.8	TECH. CORROSION INDEX	

ADDITIONAL PARAMETERS

AA CALCIUM (CA) 77. AA MAGNESIUM (MG) 44.

NOTE. PARAMETERS ARE TOTAL DISSOLVED UNLESS LABELED TR-TOTAL RECOVERABLE

DILUTE SPECIFIC CONDUCTANCE PERCENT REACTANCE VALUES

MEAS DSC 0. CALC DSC 1223. CA MG NA K CL SO4 HCO3 CO3 NO3

CALCULATED MEQ/L 0.0 35 33 31 0 2 63 35 0 0

ANALYST MG PROCESSING PROGRAM 72(REV3)

NOTE. IN CORRESPONDENCE RELATED TO THIS ANALYSIS REFER TO NUMBER 73-0683

WATER QUALITY BUREAU-MONT STATE HEALTH DEPT. HELENA, MONTANA 59601

WATER QUALITY ANALYSIS

STATE	MONTANA	COUNTY	Golden Valley
LATITUDE-LONGITUDE		LOCATION	07N 19E 12CD
SAMPLE TYPE	STREAM	LAB NO.	73-0682
GEOLOGICAL SOURCE		SAMPLE OR BOTTLE NO.	6
DRAINAGE BASIN	40A	AGENCY AND STATION CODE	WRB
DATE SAMPLED	06-13-73	DEPTH WATER ENTERS WELL	
TIME SAMPLED	1435	SWL ABOVE(+) OR BELOW GS	
DATE ANALYZED	06-29-73	ALTITUDE OF SAMPLE POINT	
SAMPLE HANDLING	1100	WATER FLOW RATE	
METHOD SAMPLED	BOTTLE	FLOW MEAS METHOD	
SANITARY CONDITION	4	PRINCIPAL USE OF WATER	MULTIPLE

PROJECT DEADMANS BASIN PROJECT VOROZILCHAK
REMARKS CARELESS CREEK ABOVE CARELESS CANAL

PARAMETERS REPORTED IN MILLIGRAMS PER LITER EXCEPT AS INDICATED

	MG/L	MEQ/L		MG/L	MEQ/L
CALCIUM (CA)	70.	3.430	BICARBONATE(HCO3)	407.	6.662
MAGNESIUM (MG)	73.	6.005	CARBONATE (CO3)	0.	0.0
SODIUM (NA)	174.	7.569	HYDROXIDE (OH)	0.	0.000
POTASSIUM (K)			CHLORIDE (CL)	0.8	0.021
TOT. IRON (FE)			SULFATE (SO4)	498.	10.373
MANGANESE (MN)			NITRATE (NO3)	.24	0.004
ALUMINUM (AL)			FLUORIDE (F)		
SILICA (SIO2)			PHOSPHATE (PO4)	.05	0.002
TOTAL CATIONS		17.054	TOTAL ANIONS		17.061

STANDARD DEVIATION OF CATION-ANION BALANCE 0.02 SIGMA

LABORATORY PH	8.30	CARBONATE HARDNESS AS CACO3	333
FIELD TEMPERATURE	19.0 C	NON-CARB. HARDNESS AS CACO3	144
CALCULATED DISSOLVED SOLIDS	1222.5	TOTAL HARDNESS AS CACO3	477
EVAPORATED SOLIDS AT 105 C		TOTAL ALKALINITY AS CACO3	333
SPECIFIC CONDUCTANCE IN		LANGLIER SATURATION INDEX	
MICROMHOS/CM AT 25 C	1110.0	RYSNAR STABILITY INDEX	
SODIUM ADSORPTION RATIO	3.5	TECH. CORROSION INDEX	

ADDITIONALABARAGNESIUM (MG) 73.

NOTE. PARAMETERS ARE TOTAL DISSOLVED UNLESS LABELED TR-TOTAL RECOVERABLE

DILUTE SPECIFIC CONDUCTANCE PERCENT REACTANCE VALUES

		CA	MG	NA	K	CL	SO4	HCO3	CO3	NO3
MEAS DSC 0.	CALC DSC 1831.									
CALCULATED MEQ/L 0.0		20	35	44	0	0	61	39	0	0

ANALYST MG PROCESSING PROGRAM 72(REV3)

NOTE. IN CORRESPONDENCE RELATED TO THIS ANALYSIS REFER TO NUMBER 73-0682

WATER QUALITY BUREAU-MONT STATE HEALTH DEPT. HELENA, MONTANA 59601

WATER QUALITY ANALYSIS

STATE	MONTANA	COUNTY	GOLDEN VALLEY
LATITUDE-LONGITUDE		LOCATION	06N 20E 02BA
SAMPLE TYPE	STREAM	LAB NO.	73-0681
GEOLOGICAL SOURCE		SAMPLE OR BOTTLE NO.	7
DRAINAGE BASIN	40A	AGENCY AND STATION CODE	WRB
DATE SAMPLED	06-13-73	DEPTH WATER ENTERS WELL	
TIME SAMPLED	1317	SWL ABOVE(+) OR BELOW GS	
DATE ANALYZED	06-29-73	ALTITUDE OF SAMPLE POINT	
SAMPLE HANDLING	1100	WATER FLOW RATE	
METHOD SAMPLED	BOTTLE	FLOW MEAS METHOD	
SANITARY CONDITION	4	PRINCIPAL USE OF WATER	MULTIPLE

PROJECT DEADMANS BASIN PROJECT VOROZILCHAK

REMARKS CARELESS CREEK JUST ABOVE MUSSELSHELL R

PARAMETERS REPORTED IN MILLIGRAMS PER LITER EXCEPT AS INDICATED

	MG/L	MEQ/L		MG/L	MEQ/L
CALCIUM (CA)	82.	4.092	BICARBONATE(HCO3)	260.	4.259
MAGNESIUM (MG)	53.	4.360	CARBONATE (CO3)	0.	0.0
SODIUM (NA)	110.	4.785	HYDROXIDE (OH)	0.	0.000
POTASSIUM (K)			CHLORIDE (CL)	9.2	0.261
TOT. IRON (FE)			SULFATE (SO4)	416.	8.668
MANGANESE (MN)			NITRATE (NO3)	.22	0.004
ALUMINUM (AL)			FLUORIDE (F)		
SILICA (SIO2)			PHOSPHATE (PO4)	.07	0.002
		------			------
TOTAL CATIONS		13.237	TOTAL ANIONS		13.194

STANDARD DEVIATION OF CATION-ANION BALANCE -0.14 SIGMA

LABORATORY PH	8.30	CARBONATE HARDNESS AS CACO3	213
FIELD TEMPERATURE	18.0 C	NON-CARB. HARDNESS AS CACO3	210
CALCULATED DISSOLVED SOLIDS	930.7	TOTAL HARDNESS AS CACO3	423
EVAPORATED SOLIDS AT 105 C		TOTAL ALKALINITY AS CACO3	213
SPECIFIC CONDUCTANCE IN		LANGLIER SATURATION INDEX	
MICROMHOS/CM AT 25 C	915.0	RYSNAR STABILITY INDEX	
SODIUM ADSORPTION RATIO	2.3	TECH. CORROSION INDEX	

ADDITIONAL PARAMETERS

AA CALCIUM (CA) 82. AA MAGNESIUM (MG) 53.

NOTE. PARAMETERS ARE TOTAL DISSOLVED UNLESS LABELED TR-TOTAL RECOVERABLE

DILUTE SPECIFIC CONDUCTANCE

MEAS DSC 0. CALC DSC 1497.

CALCULATED MEQ/L 0.0

PERCENT REACTANCE VALUES

CA	MG	NA	K	CL	SO4	HCO3	CO3	NO3
31	33	36	0	2	66	32	0	0

ANALYST MG PROCESSING PROGRAM 72(REV3)

NOTE. IN CORRESPONDENCE RELATED TO THIS ANALYSIS REFER TO NUMBER 73-0681

WATER QUALITY BUREAU-MONT STATE HEALTH DEPT.   HELENA, MONTANA 59601

WATER QUALITY ANALYSIS

STATE	MONTANA	COUNTY	GOLDEN VALLEY
LATITUDE-LONGITUDE		LOCATION	06N 20E 02BA
SAMPLE TYPE	STREAM	LAB NO.	73-0679
GEOLOGICAL SOURCE		SAMPLE OR BOTTLE NO.	8
DRAINAGE BASIN	40A	AGENCY AND STATION CODE	WRB
DATE SAMPLED	06-13-73	DEPTH WATER ENTERS WELL	
TIME SAMPLED	1310	SWL ABOVE (+) OR BELOW GS	
DATE ANALYZED	06-29-73	ALTITUDE OF SAMPLE POINT	
SAMPLE HANDLING	1100	WATER FLOW RATE	
METHOD SAMPLED	BOTTLE	FLOW MEAS METHOD	
SANITARY CONDITION	3	PRINCIPAL USE OF WATER	MULTIPLE

PROJECT DEADMANS BASIN PROJECT   VOROZILCHAK

REMARKS MUSSELSHELL R JUST ABOVE CARELESS CK

PARAMETERS REPORTED IN MILLIGRAMS PER LITER EXCEPT AS INDICATED

	MG/L	MEQ/L		MG/L	MEQ/L
CALCIUM (CA)	89.	4.441	BICARBONATE (HCO3)	267.	4.379
MAGNESIUM (MG)	57.	4.689	CARBONATE (CO3)	0.	0.0
SODIUM (NA)	115.	5.002	HYDROXIDE (OH)	0.	0.000
POTASSIUM (K)			CHLORIDE (CL)	8.5	0.240
TOT. IRON (FE)			SULFATE (SO4)	470.	9.790
MANGANESE (MN)			NITRATE (NO3)	.22	0.004
ALUMINUM (AI)			FLUORIDE (F)		
SILICA (SIO2)			PHOSPHATE (PO4)	.05	0.002
TOTAL CATIONS		14.133	TOTAL ANIONS		14.414

STANDARD DEVIATION OF CATION-ANION BALANCE 0.86 SIGMA

LABORATORY PH	8.30	CARBONATE HARDNESS AS CACO3	219
FIELD TEMPERATURE	19.0 C	NON-CARB. HARDNESS AS CACO3	238
CALCULATED DISSOLVED SOLIDS	1007.2	TOTAL HARDNESS AS CACO3	457
EVAPORATED SOLIDS AT 105 C		TOTAL ALKALINITY AS CACO3	219
SPECIFIC CONDUCTANCE IN		LANGLIER SATURATION INDEX	
MICROMHOS/CM AT 25 C	950.0	RYSNAR STABILITY INDEX	
SODIUM ADSORPTION RATIO	2.3	TECH. CORROSION INDEX	

ADDITIONAL PARAMETERS

AA CALCIUM (CA) 89.   AA MAGNESIUM (MG) 57.

NOTE. PARAMETERS ARE TOTAL DISSOLVED UNLESS LABELED TR-TOTAL RECOVERABLE

DILUTE SPECIFIC CONDUCTANCE

MEAS DSC 0. CALC DSC 1628.

CALCULATED MEQ/L 0.0

PERCENT REACTANCE VALUES

CA	MG	NA	K	CL	SO4	HCO3	CO3	NO3
31	33	35	0	2	68	30	0	0

ANALYST MG   PROCESSING PROGRAM 72(REV3)

NOTE. IN CORRESPONDENCE RELATED TO THIS ANALYSIS REFER TO NUMBER 73-0679